BRAIN-BASED LEARNING TECHNIQUES FOR MANAGING COGNITIVE OVERLOAD AND IMPROVING WORKING MEMORY AMONGST UNDERGRADUATES

A

Synopsis

Submitted in the partial fulfilment for the requirement of

DOCTOR OF PHILOSOPHY

In

PSYCHOLOGY

Submitted by
SHIVANIGINI UPADHYAY

Under the guidance of
Prof. KAMALJEET SANDHU
(Supervisor)
Head, Department of Psychology
Dean, Faculty of Social Sciences

DEPARTMENT OF PSYCHOLOGY, FACULTY OF SOCIAL SCIENCES
DAYALBAGH EDUCATIONAL INSTITUTE (DEEMED UNIVERSITY)
DAYALBAGH, AGRA-282005

2021

CONCEPTUAL FRAMEWORK

The brain starts developing even before birth. In spite of the fact that it keeps on developing all through the vast majority of life, the brain doesn't develop at a similar rate in every person. Even an individual's body develops at various rates like arriving at puberty at various ages along with emotional maturity at various times too. It also needs to be considered that a classroom full of students who are about a similar age doesn't mean they are similarly prepared to gain proficiency with a specific subject, idea, ability, or thought. It is significant for instructors and guardians to comprehend that the development of the mind impacts learning availability. For instructors, this is particularly significant while structuring exercises and choosing the systems to utilize. The answer to the choices to be made is the brain based learning system.

Brain-based learning addresses student's learning and learning outcomes from the perspective of his own brain. It includes explicit procedures that are planned depending on the way human concentration, memory, inspiration and reasonable information securing works. Brain-based learning and educating can streamline adapting comprehensively a customised way of making students learn. Brain-based learning adopts an alternate strategy that is non-conventional. The manner in which understudies are inspired, the manner in which consideration works, the manner in which recollections are shaped, the manner in which data is introduced, and so forth become the central aspect of instructing and learning. A brain-based approach doesn't really incorporate knowledge testing, aptitude testing, and other state-administered tests. While these can at times yield valuable data, but they are not required to use a brain-based methodology.

The human mind concentrates on the flight or fight reactions and can perform multiple tasks, compose and plan for unexpected and future changes (MacLean, 1978). The environment arranges the chemical balance of the brain and can change with unexpected or steady ecological disturbances (MacLean, 1978). Along these lines, a brain-based learning educational plan centred with respect to experiential learning would suit the human learner (Bonk and Graham, 2006).

Taking into account that this methodology depends on the amount of thinking about the human brain and its association with the environment, some comprehensively characterize learning objectives are

to maximize the learning capability of an individual; minimize learning destruction and wasted effort; hijack realized systems to improve aptitudes, information base, memory, and mental adaptability; create evident enhancements in learning and make individuals more brilliant; improve the profitability of students and educators.

Brain based learning isn't an approach to improve knowledge test scores. But this doesn't imply that brain-based learning can't make individuals more intelligent and score high, it just anticipates that as a result. A portion of the viewpoints associated with knowledge, for example, working memory, consideration, long-term memory, verbal familiarity, are probably going to improve because of the utilization of some specific procedures. With a central assumption that knowledge is one of a kind and changeable, the brain-based learning strategies implemented into the classroom improve students' performance and increase their chances of success. Some of the strategies may include:

1. *Set a positive tone from the beginning*- By creating a positive classroom environment where students feel supported and encouraged, students learn the best.
2. *Establish "turn and talk" time*- When students talk about concepts they've learned, they're more likely to retain the information. Implementing "turn and talk" time into lessons can help students to process what they've just read, discuss ideas before sharing them with the class, and clarify problems they may have had while completing homework.
3. *Incorporate visual elements*- According to studying style, 65 % of the people are visual learners and learn by absorbing and recalling information best by seeing.
4. *Break learning into chunks*- Chunking, or breaking down difficult or large pieces of text into smaller pieces, has been proven to help students identify key words and phrases, paraphrase, and understand the text in their own words.
5. *Get moving*- Brain breaks are a great way to get students up and moving and it increases brain activity. Brain breaks are easy to implement in any classroom setting, and they require almost no setup.

Apparently it is important to mention here that while the students are learning their working memory is functional alongside. Working memory is generally viewed as an executive function system, where

executive functions are responsible for all cognitive processes used for higher level cognition (Ilkowska & Engle, 2010). Higher level cognition includes the control of one's attention, the use of cognitive strategies, and actively searching long-term memory, among other processes. Cognitive Load Theory builds upon the widely accepted model of human information processing (Atkinson and Shiffrin 1968). It describes the process as having three main parts: sensory memory, working memory and long-term memory. Information from the sensory memory passes into the working memory, where it is either processed or discarded. Working memory can generally hold between five and nine items (or chunks) of information at any one time. When the information is too much to hold for the working memory, it cause cognition load in Working Memory (WM).

Cognitive load (CL) can be broadly defined as 'a multidimensional construct representing an individual's cognitive capacity which is used to work on a task, to learn or to solve a problem'. CL has a causal dimension which reflects the interaction between person- and task-characteristics as well as an assessment dimension, which describes the measurable aspects of mental load (ML), mental effort (ME) and performance ML is said to be task-related, indicating the cognitive capacity, which is needed to process the complexity of a task. In contrast, mental effort is subject-related and reflects an individual's invested cognitive capacity while working on a task.

The Cognition Load Theory (CLT) is the idea that data ought to be introduced at a pace and level of trouble that compares to how the human mind forms and process information. At the point when a teacher thinks about CLT, the person in question intentionally tries to bring down requests on the student's handling capacities so as to assemble perception and realize an increasingly powerful move of information into long term memory (LTM). Cognitive load theory assumes a significant role in artificial intelligence (AI) research and is material to an expansive scope of training systems for both machine learning (ML) and human cognition.

Sweller (1980) an instructive psychologist responsible for the advancement of CLT, was interested in the possibility that working memory is constrained in the number of components it can process at once. Despite the fact that specialists don't agree on the accurate number, a few investigations have demonstrated that requesting that individuals procedure in excess of seven components at the same

time causes intellectual over-burden. Sweller, in his examination inspected the idea of cognition over-burden and recognized three kinds of psychological cognition load that influence working memory:

i. Intrinsic load - those components that must be processed simultaneously.

ii. Extraneous load - those components that require extra mental handling, however, don't add to the learning experience.

iii. Germane load - those components that help the student move data from short term memory into long term memory and vice versa.

Additionally, the cognitive load is assessable and there are various methods of assessing cognitive load that are currently available can be classified along two dimensions, objectivity (subjective or objective) and causal relation (direct or indirect). The objectivity dimension describes whether the method uses subjective, self-reported data or objective observations of behavior, physiological conditions, or performance. The causal relation dimension classifies methods based on the type of relation of the phenomenon observed by the measure and the actual attribute of interest. *Direct, objective measures* of assessing are increasingly gaining importance with the use of neuroimaging techniques, this method is routinely used to visualize brain region activation in working memory studies involving simple tasks, such as word memorization, sentence comprehension, or visual rotations (Just, Carpenter, Keller, Emery, Zajac, & Thulborn, 2001).

Therefore considering the studies and the discussion above the research question that emerges is, "*What are the brain-based learning techniques that enable to reduce the cognitive load for the students and enhance their learning as well as improve the working memory?", "Are these brain-based learning techniques effective for learning?"* The thought of such a study is relevant to the conditions at large where the emphasis is on giving opportunity to everyone for learning no matter the differently brain networked students. Some studies have been done taking the variables under consideration. The summary given below highlights the outcomes and results of these studies. This also allows getting an overview about the gap and the research directions to be followed.

Table-1 Summary and Outcomes of reviewed literature related to Brain based learning and Cognitive load

Authors and year	Variables	Results and Outcomes
Costley, , Fanguy, Lange, and Baldwin, (2020)	Video lecture viewing strategies ,cognitive load	This study analyzed survey responses from a South Korean university students group (n = 2012) participating in online classes observed the mediating effect of video lecture viewing strategies on the relationship amid extraneous load and germane load. The results presented that viewing strategies mediated the relationship amid extraneous load and germane load. When viewing strategies were added to the model, the large negative relationship between extraneous load and germane load reversed to become a small positive relationship, implying that the negative correlation between extraneous load and germane load can be largely mitigated by students engaging in specific viewing strategies to better understand the content.
Hawthorne, Vella-Brodrick and Hattie John (2019)	Well-Being as a Cognitive Load Reducing Agent	The review conducted used the Scopus database concentrating on the Cognitive Load Theory Instructional Effects literature. The review recommends that well-being may perform as a cognitive load reducing agent for students and propose evidence from the broader literature on mechanisms through which well-being reduces the cognitive load placed upon a student's working memory. The proposed mechanisms of decreasing extraneous load and enhancing germane load are projected through; the presence of positive emotions, the absence of painful emotions, high levels of academic buoyancy, and cognitive regulation.
Magno, (2018)	Metacognitive Reading Strategy, Emerging Reading Comprehension, and Intellectual disability.	Many students with intellectual disabilities (ID) struggle with reading comprehension skills, which can affect their overall academic success. Finding effective evidence-based instructional strategies that will advance reading comprehension for students with special learning needs is often challenging for schools and districts. Using Unique Learning System's content and instructional delivery platform, this study tested the effectiveness of a metacognitive reading strategy on the emerging reading comprehension (ERC) skills of kindergarten students with ID. The program's scaffolding approach, enabling educators to chunk information to support students with working memory deficits, resulted in significant improvements in the ERC skills of the study participants.

Condon, (2017)	Standard-based instructions, Achievement levels, and intellectual disabilities.	The motivations behind this research were to gauge the view of middle school specialized curriculum teachers—just as the guardians of their students—on the adequacy of their Unique Learning System implementation. Also, the researcher looked to plan an activity intend to empower Ocean Front School District specialized curriculum administrators and teachers to decide the adequacy of the program's standards-based content, instructional methodologies, accommodations, and modifications. The investigation gathered information through teacher interviews, reflective journaling, and checklists that measured students' independent participation. Parent recognitions were estimated through rating scales. As per the findings, the two educators and guardians see that Unique Learning System has positively affected the scholastic and useful accomplishment of students with intellectual inabilities. The activity plan proposes continuous expert advancement of a Unique Learning System for educators, paraprofessionals, and guardians.
Estacio, and Raga Jr (2017)	Online Learning Behaviour, Blended Courses, and Moodle	The purpose of this paper is to describe a proposal for a data-driven investigation aimed at determining whether students' learning behavior can be extracted and visualized from action logs recorded by Moodle. The paper also tried to show whether there is a correlation between the activity level of students in online environments and their academic performance with respect to final grade. This work has shown that data mining algorithm like vector space model can be used to aggregate the action logs of students and quantify it into a single numeric value that can be used to generate visualizations of students' level of activity. The current investigation indicates that there is a lot of variability in terms of the correlation between these two variables.
Prisacari and Daneilson (2017).	Cognitive Load, Scratch paper.	The aim of the present study was to explore the relationship between testing mode (taking a test on computer versus paper) and two other factors: (1) cognitive load and (2) scratch paper use in an undergraduate general chemistry class setting. 221 students completed three assessments administered either on computer or paper. There was no significant difference in the cognitive load imposed by computer or paper-based tests at the overall test level or by question type. Students utilized scratch paper more on paper-based than online tests, especially when the questions were conceptual, and they used scratch paper the most for algorithmic questions.

Uzezi and Jonah, (2017).	Brain-based learning, electrochemistry, academic achievement, attitude, motivation, knowledge retention	The purpose of this study was to examine the effect of Brain-Based Learning strategy on students' academic achievement, attitude, motivation and knowledge retention in Electrochemistry. The study used a pretest-posttest quasi-experimental design. A total of 87 Senior Secondary Two students from two intact classes from North-Eastern part of Nigeria with an average age of 17 years of 2015/2016 academic session participated in this study. The findings of the study revealed that the Brain-Based Learning approach used in the experimental group was more effective in increasing student achievement, attitude and motivation of students towards chemistry than the Lecture-Based approach used in the control group. It was identified that the difference between retention test scores were also statistically significant in favour of experimental group.
Bonomo (2017)	Brain-Based Learning Theory.	The purpose for this study was to examine whether or not gender-specific strategies improve boys' reading achievement. The purpose of this study is to examine whether there is a correlation between gender-specific literacy instruction and the reading achievement of boys in single-gender schools. This review will begin by defining brain-based learning theory and drawing a connection to cognitive gender differences, which will provide a theoretical framework on which to base this study. The results shows that there is a gap in the literature regarding the impact of single-gender education and the reading achievement of boys.
Varghese and Pandya (2016).	Effectiveness of Brain-Based- Learning	This study focused on effectiveness of brain-based learning on academic achievement, study habits and stress of students at the secondary level. The Quasi- Experimental method used by researcher and the design implemented is factorial design- the pre-test, posttest quasi-experimental design. The research emphasizes brain- based learning as a self-perpetuating neurocognitive approach towards, pure joys of learning that results in 'learning celebrations'. The researcher recommends the exhaustive application of this approach for effective classroom transactions and advocates the academicians and educators to publicize it ross the globe for the benefit of the learner community.

Wang, Cesar, (2015).	GSR sensors	Measuring students' engagement in a distributed learning environment is a challenge. In particular, a teacher gives a lecture at one location, while at the same time the remote students watch the lecture through a display screen. In such situation, it is difficult for the teacher to know the reaction at the remote location. In this paper, we conducted a field study to measure students' engagement by using galvanic skin response (GSR) sensors, where students simultaneously watched the lecture at the two locations. Our results showed the students' GSR response was aligned with the surveys, which means that during a distributed learning environment, GSR sensors can be used as an indicator on students' engagement. Furthermore, our user studies resulted in non-engaging student learning experiences that would be difficult obtained at a lab condition. Based on the findings, we found that the patterns of GSR readings were rather different when compared to the previous relevant studies, where users were engaged. In addition, we noticed that the density of GSR response at the remote location was higher when compared to the one at the lecture room. We believe that our studies are beneficial on physiological computing, as we first presented the patterns of GSR sensors on non-engaging user experiences. Moreover, as an alternative method, GSR sensors can be easily implemented in a distributed learning environment to provide feedback to teachers.
Haward, Burianova, Ehrich, Kervin, Calliea and Barkus et al. (2015).	Cognitive Load, Behaviour	Standards-referenced educational reform has increased the prevalence of standardized testing; however, whether these tests accurately measure students' competencies has been questioned. This may be due to domain-specific assessments placing a differing domain-general cognitive load on test-takers. To investigate this possibility, functional magnetic resonance imaging (fMRI) was used to identify and quantify the neural correlates of performance on current, international standardized methods of spelling assessment. Out-of-scanner testing was used to further examine differences in assessment results. Results provide converging evidence that: (a) the spelling assessments differed in the cognitive load placed on test-takers; (b) performance decreased with increasing cognitive load of the assessment; and (c) brain regions associated with working memory were more highly activated during performance of assessments that were higher in cognitive load. These findings suggest that

		assessment design should optimize the cognitive load placed on test-takers, to ensure students' results are an accurate reflection of their true levels of competency. In the context of the current study, doing so would require redefinition of the abilities that tests assess (i.e., spelling vs. proofreading) or the redesign of assessments to ensure that the target knowledge or skills are accurate reflected in students' results.
Gozuyesil, and Dikici, (2014)	Brain-Based Learning, Academic Achievement.	This study's aim is to measure the effect sizes of the quantitative studies that examined the effectiveness of brain-based learning on students' academic achievement and to examine with the meta-analytical method if there is a significant difference in effect in terms of the factors of education level, subject matter, sampling size, and the countries where the studies were carried out. The findings indicate that 35 out of 42 comparisons had positive effect sizes. It revealed that brain-based learning has a positive but medium effect (d = 0.640) on students' academic achievement. In addition, when compared with the studies conducted in Turkey and the USA, it drew the conclusion that there is a significant difference between the groups while there is no difference in any effect sizes in terms of education level, subject matter and sampling size.
Erkan, and Ozlem, (2013).	Brain-Based Learning Approaches, Motivation and Attitudes.	The purpose of the study was to examine the effect of brain-based learning approach on attitudes and motivation levels in 8th grade students' science classes. The pre/post-test control group research model was used in this study. Totally 57 students, 19 in experimental group, 19 in each control groups participated in this research. As a result, using brain-based learning approach the experimental group's success was found to be significant differences in favour of the experimental group. Brain-based learning approach used in the experimental group's achievement test scores of control group's achievement was determined to be statistically significant difference in favour of the experimental group.
Kiedinger, (2011).	Brain-Based Learning, Reading Outcome.	The purpose of this study is to examine the effects of brain-based learning within the 2 framework of two elementary schools that administer the Wisconsin Knowledge Concepts Exam. The method used was a survey designed by the researcher and distributed to the faculty of the students in grades three, four and five. The study found an increase in Reading scores

		as measured by the WKCE. The most significant change originated in students on the lower end of the continuum. This can be attributed to the current understanding that students scoring proficient or advanced had brains that were more efficient at the task of evaluating and analysing text; therefore, the brains of these students did not require the extra enrichment provided by brain-based learning; however, for students at the lower end of the continuum, brain-based learning necessitated an increase in scores. There was positive correlation between brain-based learning strategies and expected student achievement for these students.
Aydin, and Yel (2011).	Brain-based Learning Biology Education, Attitude, and Academic Success.	The aim of this study is to explore the effect of the learning environment, equipped with activities prepared according to the Brain-Based Learning Theory, on academic achievements and biology course attitudes of ninth grade students, compared to the conventional learning environment. The research was conducted with 44 students placed in experiment and control groups and selected from the ninth grade students of a high school during the 2007-2008 academic year in Ankara through the objective appointment method. After the analysis, it was determined that teaching the subject of substance transportation in cell with brain-based learning activities increases student achievement. In addition, it was concluded that the brain-based teaching does not create any difference in students' attitudes towards the biology course.
Saleh, and Salmiza, (2011).	Brain-Based Learning Approaches and Learning Motivation.	The aim of this study was to measure the effectiveness of the BBTA (brain-based teaching approach) in dealing with issues related to the learning motivation towards the subject of physics amongst secondary school students in Malaysia. This research sample constitutes 100 Form Four science stream students from two science secondary school in the Northern Peninsular, Malaysia. The findings of this study showed that the BBTA module was an effective teaching approach in dealing with the issue aforementioned. It was found that students who followed the BBTA module possessed a better physics learning motivation compared to students who received CTM (conventional teaching method).
Duman, (2010)	Brain-based Learning, different learning style.	The purpose of the present study is to investigate the effects of Brain-based learning (BBL) on the academic achievement of students with different learning styles. The study group consists of students from the department of Social Sciences

		Teacher Education in the Faculty of Education at Mugla University (N=68). In the study, a pre-test-post-test experimental design was used. Data were collected by using academic achievement tests and the Kolb's Experiential Learning Style questionnaire. The findings of the study revealed that the BBL approach used in the experimental group was more effective in increasing student achievement than the traditional approach used in the control group. However, no significant difference was observed among the achievement levels of the experimental group students with different learning styles.
Antonenko, Pass, Grabner, & Geg, (2010).	EEG, Cognitive load	Application of physiological methods, in particular electroencephalography (EEG), offers new and promising approaches to educational psychology research. EEG is identified as a physiological index that can serve as an online, continuous measure of cognitive load detecting subtle fluctuations in instantaneous load, which can help explain effects of instructional interventions when measures of overall cognitive load fail to reflect such differences in cognitive processing. This paper presents a review of seminal literature on the use of continuous EEG to measure cognitive load and describes two case studies on learning from hypertext and multimedia that employed EEG methodology to collect and analyse cognitive load data.
Kella, Downes & Broek, (2010)	Pre-Exposure technique, Effects of effortless learning, Face name association.	The present study examines whether the technique of errorless learning, recently applied in neuropsychological rehabilitation, might also benefit from pre-exposure. The rationale for hypothesising such an interaction follows from the speculation raised in our earlier work that the two techniques may be operating at different stages of learning—pre-exposure at registration/consolidation stages and errorless learning at retrieval. Accordingly, a group of brain-injured memory-impaired subjects was given four sets of face-name associations to learn under different experimental conditions. Two of these conditions compared errorless and errorful conditions, and two combined errorless learning with different versions of the pre-exposure technique. The results confirm that, in terms of the number of names learned on the first trial and the number of trials to criterion, errorless learning was significantly superior to errorful learning. Furthermore, both pre-exposure conditions in combination with errorless learning resulted in a significant

		enhancement of learning compared to errorless learning alone. Thus, as with imagery, although significant gains in performance are evident when errorless learning is used, further enhancement can be achieved by combining it with pre-exposure.
Haapalainen, Pass, Grabner, & Geg, (2010).	Psycho-Physiological Measures, Cognitive load	With a focus on presenting information at the right time, the ubicomp community can benefit greatly from learning the most salient human measures of cognitive load. Cognitive load can be used as a metric to determine when or whether to interrupt a user. In this paper, researchers collected data from multiple sensors and compared their ability to assess cognitive load. Researcher's focus is on visual perception and cognitive speed-focused tasks that leverage cognitive abilities common in ubicomp applications. Researchers found that across all participants, the electrocardiogram median absolute deviation and median heat flux measurements were the most accurate at distinguishing between low and high levels of cognitive load, providing a classification accuracy of over 80% when used together. Researcher's contribution is a real-time, objective, and generalizable method for assessing cognitive load in cognitive tasks commonly found in ubicomp systems and situations of divided attention.
Paas, Gog, & Sweller, (2010).	Cognitive Load Theory.	The articles of this special issue on cognitive load theory discuss new conceptualizations of the different categories of cognitive load, an integrated research perspective of process-oriented and cognitive load approaches to collaborative learning, an integrated research perspective of cognitive and social–cognitive approaches to example-based learning, and a specification of the theory focusing on the acquisition of generalized knowledge structures as a means to facilitate flexible problem-solving skills. This article provides a short introduction to the theory, discusses some of its recent advances, and provides an overview of the contributions to this issue. In conclusion, they believe that the papers of this issue attest to the continuing strength and usability of CLT. For many years, the theory has provided a source of novel, instructional design procedures. The current papers provide evidence that it is capable of continuing to do so.
Tüfekçi and Demirel, (2009).	Brain based learning, achievement, retention, attitude and learning process	The objective of this research is to determine the effect of learning organized instruction which designed according to the brain based learning on achievement, retention, attitude and the

		learning process. Control grouped pre-test post-test experimental design has been applied in the research and qualitative data related to the learning process has been reached with an interview technique. The research revealed that brain based learning environment has a positive effect on the higher level learning, retention of the learning and the attitude toward course of the university students.
Ozden, and Gultekin, (2008).	Brain-Based Learning, Academic Achievement, and Retention of knowledge.	The aim of this study is to investigate the effects of brain-based learning in a 5th grade Science course on academic achievement and retention of previously acquired knowledge. This experimental study, which was designed as pre- and post-test control group model, was conducted in 2004-2005 academic year at Kütahya Abdurrahman Pasa Primary School in Kütahya, Turkey. Two classes, namely 5-A and 5-B, were determined as experimental and control groups respectively. The participants of this study were 22 fifth graders from each group. The study lasted 11 days for a total of 18 class hours. During the research process, the experimental group was administered a brain-based learning approach, while the control group was administered a traditional teaching approach. Analysis of post-test and retention level tests revealed a significant difference between the groups favouring brain-based learning.
Jeroen, Merriënboer, and Ayres, (2005)	Cognitive Load Theory, e-leaning.	This introduction to the special issue provides a context for the contributing articles. For readers who are not familiar with cognitive load theory (CLT), it provides a very brief description of assumptions regarding memory systems and learning processes, different types of cognitive load (intrinsic, extraneous, and germane), and design implications. Whereas traditional CLT research focused on instructional methods to decrease extraneous cognitive load that is not directly relevant for learning, contributions to this special issue represent wider perspectives that reflect new developments in CLT. These articles have been organized into three categories: (a) methods to decrease intrinsic cognitive load, and deal with high-element interactivity materials, (b) methods to increase germane cognitive load that is directly relevant for learning, and (c) methods to deal with differences in learner's individual levels of expertise and expertise development. To conclude, design implications for (adaptive) e-learning are discussed.

Shapiro, (2004)	Prior Knowledge	Prior knowledge has a marked effect on learning outcomes. This experiments demonstrate that such methodological controls may be insufficient. In Experiment 1, students read texts about fictional places and events. In Experiment 2, novice students in a cognition course were asked to read several advanced texts. In both experiments, prior knowledge accounted for a large portion of the subjects' post-test performance. The data demonstrate that methodological approaches intended to control for prior knowledge may be insufficient to prevent that variable from influencing learning outcomes. Thus researchers are urged to include measures of prior knowledge in their analyses.
Farrand, Hussain, & Hennessey, (2002)	Mind Map Technique	To examine the effectiveness of using the 'mind map' study technique to improve factual recall from written information. To obtain baseline data, subjects completed a short test based on a 600-word passage of text prior to being randomly allocated to form two groups: 'self-selected study technique' and 'mind map'. Subjects in the mind map group were trained in the mind map technique and told to apply it to the passage of text. Recall was measured after an interfering task and a week later. Recall of factual material improved for both the mind map and self-selected study technique groups at immediate test compared with baseline. However this improvement was only robust after a week for those in the mind map group. At 1 week, the factual knowledge in the mind map group was greater by 10% (adjusting for baseline) (95% CI -1% to 22%). However motivation for the technique used was lower in the mind map group; if motivation could have been made equal in the groups, the improvement with mind mapping would have been 15% (95% CI 3% to 27%). Mind maps provide an effective study technique when applied to written material. However before mind maps are generally adopted as a study technique, consideration has to be given towards ways of improving motivation amongst users.
Green, (1999).	Brain structure, multiple intelligence, learning styles, emotions and learning, music and cognitive development, and brain-based learning.	This article provides a brief overview of current brain and learning research and discusses the implications of the research in meeting the needs of diverse learners in the classroom. The author describes dramatic developments in brain research related to brain structure, multiple intelligence, learning styles, emotions and learning, music and cognitive development, and brain-based learning. On the basis of the research, the author proposes the need for

		multifaceted, complex instruction and resource-rich environments for students. She asserts the each and every child has a unique brain and a great capacity to learn when exposed to relevant learning strategies. The results of this study suggest the need for a longitudinal study to deter1mine possible cause and effect between the variables and academic achievement.
Wexley, Nameroff, (1975)	Positive reinforcement, Goal setting, and management Development.	A total of 22 female and 5 male managers in a medical centre to 1 of 2 managerial training programs or a no-treatment control group. One program involved role playing, together with delayed appraisal sessions and assigned goal setting; the other involved role playing with delayed appraisal sessions, assigned goal setting, and immediate reinforcement via tele-coaching. Measures of managerial behavior and subordinate satisfaction were collected 60 days after the completion of training. Results indicate that the training programs were statistically more effective than no treatment in improving the consideration and integration skills of managers and reducing the absenteeism of their subordinates, although the programs were not statistically different from each other. The success of both treatments was accomplished without any undesired reduction in the managers' general level of initiating structure or production emphasis. The program involving delayed appraisal sessions and assigned goal setting was most effective in increasing subordinate work satisfaction.

Rationale of the study, research gap and future research directions

Several studies have been conducted in which brain-based learning strategies and cognitive load have been studied individually, but so far no study has been conducted in which brain-based learning strategies and cognitive load have been studied together.

Working memory is essentially individuals' mental bandwidth. If they have good working memory, or can use it more effectively, they can think and learn better. Thus, understanding this important facet of mind it is essential for anyone who wants to perform better in work, school and life. Working memory is a key aspect of intelligence. Much of the learning depends on working memory that an individual has. Sometimes learning involves great efforts and sometimes even suffering. That's because working memory is quite vulnerable to overload, which occurs as one studies increasingly complex subjects and perform increasingly complex tasks. As learning experience designers, our concerns is definitely

to watch out for cognitive load, which refers to the total amount of mental activity imposed on working memory in any one instant.

We don't need to always focus on improving cognitive abilities like attention, memory, mental simulations, mental rotations, pattern matching, analysing concepts, hypothetical and counterfactual thinking, intelligence, verbal ability, and sensory awareness. Sometimes, the problem is more about emotion, motivation, behavior, and mental health. Cognition and emotions aren't unrelated entities so one may impact the other. We need to think about the use of memory training if a person has no inclination or intention to use it. So, the researcher desires to focus on managing cognitive load and changing understanding of the students for better performance with working memory. Cognitive load as the weight of information and the strain on processing information does not allow students especially in semester system to assimilate information. The rush during the semester to grasp the recommended information is creating a load on the students and hence impacting their performance at large. Changing the efforts needed to process information can promote learning. The brain is plastic as it can change its form and neural structures until old-age to accommodate and allow new learning.

Brain-based learning techniques refer to teaching methods, lesson designs and programs that are based on the latest scientific research about the way the brain learns, including such factors as cognitive development where students learn differently as they age, grow and mature socially, emotionally and cognitively. Brain-based learning focusing on neuroplasticity as the concept that neural connections in the brain change, remap, and reorganize themselves when people learn new concepts, have new experiences or practice certain skills over time. The research has an idea to derive certain BBL techniques that will enable better learning experience for the students. The conceptual framework formulated is as below:

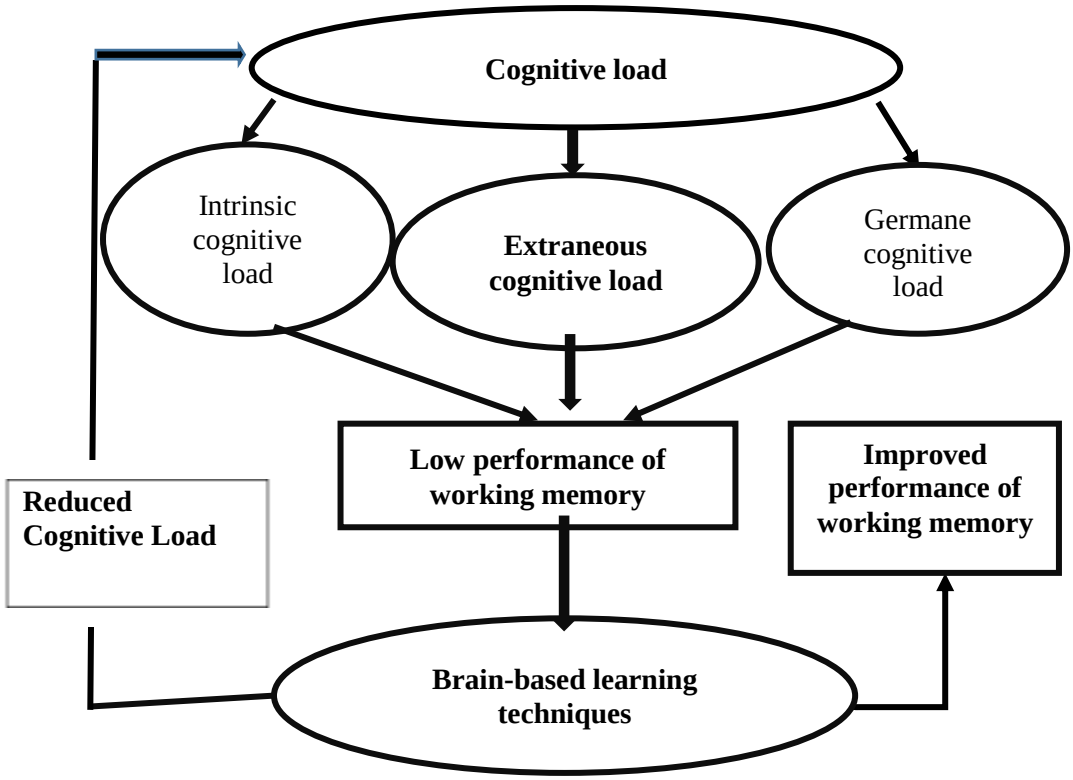

Figure 1: Conceptual Framework of the study

OBJECTIVES

1. To assess the cognitive load and level of working memory amongst undergraduate students
2. To identify and explore effectiveness of the BBL techniques in helping undergraduate students for managing the cognitive overload and improving their Working Memory.

HYPOTHESIS

BBL techniques would be effective in showing significant reduction in cognitive overload and improving working memory of the undergraduate students.

VARIABLES

Independent Variable:

- Brain-Based Learning Techniques [Pre-Exposure; Goal setting; Mind-Mapping; Prior knowledge; Retrieval; Elaboration; Interleaving and Spaced Practice]

Dependent Variable:

- Cognitive Load
- Working Memory

OPERATIONAL DEFINITIONS OF THE TERMS USED

Brain-based Learning: alludes to teaching strategies, exercise plans and programs that depend on the most recent scientific research about the way the brain picks up information.

Cognitive Load: refers to the used amount of working memory resources, such as memory, perception, learning etc. as well as the pressure created on the brain due to the amount of information processing to be done. Paas define it as "the cognitive capacity that is actually allocated to accommodate the demands imposed by the task; thus, it can be considered to reflect the actual cognitive load".

Working memory: is the part of short-term memory, which is concerned with immediate conscious perceptual, linguistic and information processing

SAMPLE DESCRIPTION

The study will be conducted on a stratified randomly selected [on the basis of education, age, I.Q., and gender] sample of 400 undergraduate students studying in various programs of colleges, educational institutes and universities of Agra (U.P.) in India. Prior permission from the authorities for conducting the research work will be acquired. Both male and female undergraduate students will be included in the study. Paas's (1992) Nine-point Mental Effort Rating Scale and Wechsler's Adult intelligence Test (WAIS-IV, 2008) for working memory and Intelligence score will be administered to generate data. Out of these 400 students those high on cognitive load and low on working memory; willing to participate in the intervention program will be purposively selected for the intervention with identified and validated Brain based learning techniques. The inclusion and exclusion criteria are as given below:

Inclusion Criteria

1. Age of students between the ranges of 19-22 years.
2. Educational Qualification: undergraduate.
3. Type of colleges- Private, government, and universities.
4. I.Q. level should be average of all students.

Exclusion Criteria

1. Subject should not be especially abled or have any kind of learning disability.
2. Subject should not be currently undergoing any psychological treatment or therapy.
3. Irregular students will not be involved in this study.

TOOLS

Cognitive load

Paas's (1992) Nine-point Mental Effort Rating Scale will be used to generate data for cognitive load. It is a one-dimensional 9-point symmetrical rating scale which asks participants to rate how much mental effort they invested in a task, ranging from (1) very low mental effort, to (9) very, very high mental effort. Mental effort has been defined by Paas as "the cognitive capacity that is actually allocated to accommodate the demands imposed by the task; thus, it can be considered to reflect the actual cognitive load". The 9-point scale is highly reliable 0.95. This scale is having high and good content validity (0.85).

Working memory

The **Wechsler Adult Intelligence Scale (WAIS-IV, 2008)** will be used to generate data on working memory. The WAIS-IV measure is appropriate for individuals in between 16–90 years of age. In the fourth edition of the test (WAIS-IV), the subtests Digit Span and Letter-Number Sequencing are expanded for better measurement of working memory (WM). The test-retest reliability ranges from 0.70 (7 subscales) to 0.90 (2 subscales). Inter-scorer coefficients are very high, all being above 0.90.

Brain-Based Learning Techniques

1. **Pre-Exposure-** is to expose to the learning material in advance or prematurely. Pre-exposure to information to be learned is at times labelled as priming that makes successive learning advance more quickly. The human brain in a way puts the information and ideas into a "*buffer zone*" for speedy access. If the information over time is not being utilized, it just remains random as well as unconnected. Simultaneously, if the additional parts of a puzzle are presented, the understanding of meaning is prompt. Kalla, Downes and van den Broek (2001) in an initial research established the beneficial effects of imagery in face-name association

learning task that is enhanced by simple expedient of pre-exposing faces for brief period earlier to exposing the names to be associated.

2. **Goal setting** comprises of the development of action plan intended to motivate and guide an individual or group in the direction of a goal. Goals help to regulate priorities and direct focus on important aspects. A study by Waxley and Nemeroff (1975) proposed that assigned goal setting was most effective in enhancing subordinates' work satisfaction.
3. **Mind-Mapping-** is creating a graphic visual display of individual showing significant relationships with symbols, colours, and buzz words, which is meaningful for the learner. Mind mapping is extremely effective with information going in and out of brain. A creative as well as logical way of note-taking and note-making, mind mapping "*maps out*" ideas. Farrand, Hussain, and Hennessey (2002) recommended mind map as memory improving strategy for written information. The technique has potential for a significant improvement in efficacy. Using mind map technique there is a projected increase of 10% without any change in motivation, and escalation of 13% with a change. Therefore, the technique may also help in reducing cognitive load of the students.
4. **Prior knowledge-** With activation of prior knowledge, the brain is more probable to establish connections to any new material, therefore enhancing comprehension and meaning. Anderson and Pearson (1984) revealed the importance of determining and relating to previously learned material to be much greater. Shapiro in an experiment (2004), recommended that prior knowledge remarkably effect learning outcomes.
5. **Retrieval-**is accessing learned information and is activated by retrieval cues that may be a question, experience or event activating allied knowledge. Retrieval cues are significant as they are vital for unlocking the information. Retrieval-based learning is a relevant strategy for long-term retention as it includes constantly recalling information through numerous recall sessions.
6. **Elaboration** : Students in some way essentially talk about, argue, think, summarize, inquire, rewrite as well as recall the learning to cultivate depth of elaboration. Considering significant

relationships; transform content by converting a summary into a song, an object, a mural or map it; discover novel meaning from the existing content with study, discussion; finding a novel association of content by viewing its larger context or seeing categories within it; uncover details inside the main ideas from content searches with main ideas devising sub topics and details are all aspects related to elaboration used as a technique for brain based learning.

7. **Interleaving***:* As per cognitive psychologists interleaving enhances the brain's ability to differentiate or discriminate, amid concepts and reinforces memory associations. More vital in the process is the amount of recall that is essential. Our sophisticated brain continually is employing diverse pieces of knowledge to solve problems encountered, where in the process it constantly needs to retrieve stuff from the long-term memory. Therefore, by employing interleaving the learners immensely increase the long-term retention of information learned.
8. **Spaced Practice***:* combined with retrieval practice force brain to search for connected information and generate innovative connections that improve the learning quality. The optimal timing amid the study sessions varies, subject to the desired retention period and material reviewed by students over a long period of time. This provides their minds with time to form connections amid the ideas and concepts so as to build upon knowledge and recalled later easily. While our brains almost forgot the material, it works harder to recall that information thus deepening the memory traces. Spaced learning gives students a brain workout whenever they revisit the material.

PHYSIOLOGICAL MEASURES

- **Electroencephalogram (EEG):** is a test used to evaluate the electrical activity in the brain. Brain cells communicate with each other through electrical impulses. An EEG can be used to help detect potential problems associated with this activity. An EEG tracks and records brain wave patterns. Small flat metal discs called electrodes are attached to the scalp with wires. The electrodes analyse the electrical impulses in the brain and send signals to a computer that records the results.

- **Galvanic Skin Response (GSR):** Originates from the autonomic activation of sweat glands in the skin. The sweating on hands and feet is triggered by emotional stimulation: Whenever we are emotionally aroused, the GSR data shows distinctive patterns that are visible with bare eyes and that can be quantified statistically. The skin tells everything – our skin gives away a lot of information on how we feel when we're exposed to emotionally loaded images, videos, events, or other kinds of stimuli – both positive and negative. No matter whether we are stressed, nervous, fearful, psyched up, stoked, baffled, or surprised – whenever we are emotionally aroused, the electrical conductivity of our skin subtly changes.

PROCEDURE: Out of a stratified random sample of 400 undergraduate students those high on cognitive load and low on working memory will be purposively selected for the BBL techniques intervention. Physiological measures will be done on purposively selected sample before and after intervention to know about the physiological changes like emotional arousal, skin responses, brain waves due to cognitive overload and low working memory. The data obtained after administration of Paas's (1992) Nine-point Mental Effort Rating Scale for cognitive load and Wechsler's Adult intelligence scale for working memory will serve as the pre measure. Thereafter, the students will be given the intervention. The students who are willing to participate in the intervention will then be divided randomly into eight groups and will be given six weeks intervention using the eight BBL techniques identified. After the intervention a post test will be taken for working memory, perceived cognitive load and Physiological measure. The conditions for pre- test and post- test will be maintained the same.

RESEARCH DESIGN

To analyse and compare the effectiveness of brain based learning techniques pre and post-test design will be used.

STATISTICAL TECHINQUES

Kruskal Wallis ANOVA will be used to analyse the data and compare the groups, along with post hoc Dunn's Test (Pairwise Multiple Comparison Test) that will be used to analyse the data to know how many possible combinations' are significant.

ANALYSIS THROUGH CASE STUDIES

The aim of the qualitative analysis is to explore the recreation, integration, and synthesizing of learned material through a cognitive task on selected cases.

Group of six extreme cases students will be selected for conducting a qualitative analysis, after 20 days gap the six extreme cases (those who showed very good improvement and very less improvement) will be given a cognitive task with selected material/concept related to any general concept. Before the conduction of the task a pre-measure of working memory, cognitive overload, and physiological data will be taken then Think-Pair-Share strategy will be used to understand the recreation, integration, and synthesizing of the learned material.

Think-Pair-Share Technique

Think-pair-share is a collaborative learning strategy where students work together to solve a problem or answer a question about an assigned reading. This strategy requires students to:

(1) Think individually about a topic and recreate it.

(2) Share ideas with the other student and integrate the learned material.

(3) Share ideas with the whole class/group and synthesize the learned material.

PROCEDURE FOR COGNITIVE TASK

Task 1- After the pre-measure (working memory, Cognitive Overload, and physiological data-EEG, GSR) the selected students will be given the selected material to read and think. They will be asked to produce or recreate write-up of the same material individually. After which post measure will be taken, the conditions for the pre and post measure will be the same. The group will then be subjected to a break for one week during which the BBL technique showing the best results previously in the study will be conducted during the break.

Task 2- In the second task the group will be randomly paired and after reading the material they will be allowed to discuss in pairs and then write the same material, which will indicate how well they can

integrate the information. The scores of pre and post measure before and after the task will be compared using Wilcoxon-T. An introspection report will be taken from the subject to know if the pairing helped them in any way to reduce the feeling of cognitive overload, if any. Then the group will again be given a break of one week with BBL technique conducting during the break.

Task 3- Finally, the group will be allowed for a group discussion on a concept and then write about that concept, indicating how well they are able to synthesize the material. As per the procedure the pre-post measure (working load, Cognitive overload, and Physiological data) will be taken to compare any change brought about by sharing. Introspection report will be taken from the subjects thereafter.

After the study with the cognitive tasks the data for all the three tasks will be qualitatively as well as quantitatively analysed to find out the difference in the recreation, integration and synthesizing of the learned material.

STATISTICAL TECHNIQUE

Wilcoxon-T test and content analysis will be used.

References

- Atkinson, R. C., & Shiffrin, R.M. (1968). Human Memory: A Proposed System and its Control Process. *The Psychology of Learning and Motivation,* (ed. 2nd), New York: Academic Press.
- Antonenko, P., Pass, F., Grabner, R., & Geg, T.V. (2010). Using Electroencephalography to measure Cognitive Load. *Educational Psychology Review* 22, 425-438.
- Aydin, S., & Yel, M. (2011). The Effect of Brain-Based Learning Biology Education upon the Academic Success and Attitude. *EEST Part B: Social and Educational Studies, 3*(1), 87-98.
- Bonomo, V. (2017). Brain-Based Learning Theory. *Journal of Education and Human Development, 6*(1), 27-43
- Brown, P. C., Roediger, H. L., & McDaniel, M. A. (2014). Make It Stick. Harvard University Press
- Brunken, R., Plass, J. L., & Leuther, D. (2003). Direct Measurement of Cognitive Load in Multimedia learning. *Journal of Educational Psychologist, 38*(1), 53-61.

- Cognitive Load Theory, (2019). Retrieved from: https://psychologistworld.com/memory/cognitive-load-theory as on 5/11/2019.
- Costley, Jamie , Fanguy, Mik, Lange, Chris & Baldwin, Matthew (2020). The effects of video lecture viewing strategies on cognitive load, *Journal of Computing in Higher Education*, Retrieved from https://doi.org/10.1007/s12528-020-09254-y as on 18.05.2020
- Condon, A. W. (2017). Impact of Standards-Based Instruction on Achievement Levels of Students with Moderate to Severe Intellectual Disabilities: An Action Research Study. (Doctoral dissertation). Retrieved from *https://scholarcommons.sc.edu/cgi/viewcontent.cgi?referer=&httpsredir=1&article=5221&context=etd*
- Duman, B. (2010). The Effect of Brain-Based Learning on the Academic Achievement of Students with different Learning styles. *Educational Sciences: Theory and Practice, 10*(4), 2077-2103.
- Estacio, R.R. and Raga Jr, R.C. (2017). Analysing students' online learning behavior in blended courses using Moodle. *Asian Association of Open Universities Journal*, *12*(1), pp. 52-68.
- Egeland, J. (2015). Measuring Working Memory with Digit Span and the Letter-Number Sequencing Subsets from the WAIS-IV: Too Low Manipulation Load and Risk for understanding modality effects. *International Journal of Applied neuropsychology, 22*(6), 445-451.
- Erkan, Y., & Ozlem, A. (2013). Effect of Brain-Based Learning Approach on Students' Motivation and Attitudes Level in Science Class. *Mevlana International journal of Education (MIJE), 3*(1), 104-119.
- Farrand, P. A. Hussain, F. & Hennessey, E. (2002). The efficacy of the "mind-map" study techniques. *International Journal: Medical Education, 36(5), 426-431.*
- Gozuyesil, E., & Dekici, A. (2014). The Effect of Brain-Based Learning on Academic Achievement: A Meta-Analytical Study. *The Journal of Educational Sciences: Theory and Practice, 4*(2), 642-648.

- Green, F. E. (1999). Brain and Learning Research: Implications for Meeting the Needs of Diverse Learning. *International Journal: Education, 119*(4), 682-687.
- Hawthorne Benjamin. S, Vella-Brodrick Dianne. A. and Hattie John (2019). Well-Being as a Cognitive Load Reducing Agent: A Review of the Literature, *Frontiers in Education, Retrieved from* Front. Educ., 23 October 2019 | https://doi.org/10.3389/feduc.2019.00121, as on 18.05.2020
- Howard, S.J., Burianova, H., Ehrich, J., Kervin, L., Calleia, A., &Barkus, E. et al. (2015). Behavioural and FMRI Evidence of the Differing Cognitive Load of Domain-Specific Assessments. *International Journal of Neuroscience, 297*(25), 38-46.
- Haapalainen, E., Kim, S., Forlizzi, J.L., & Dey, A.k. (2010). Psycho-Physiological measure for assessing cognitive load. *UbiComp'10: Proceeding of the 12th ACM international conference on ubiquitous computing.* 301-310.
- Jenson, E. (2005). Brain-Based techniques. Brain-Based Learning: The New science of Teaching and Training. Delhi, U.P.: Pearson Education.
- Jeroen, J. G., Merrienboer, V., & Ayres, P. (2005). Research on Cognitive Load Theory and its Design Implications for e-learning. *The Journal of Educational Technology Research and Development, 53*(3), 5-13.
- Kalla, T., Downes, J. J., & van den Broek, M. (2001). The pre-exposure technique: Enhancing the effects of errorless learning in the acquisition of face–name associations. *Neuropsychological Rehabilitation, 11*(1), 1–16.
- Kane, T. M. (September 11, 2013). Brain-Based Learning Theory. Retrieved From: *https://pearsoned.com/brain-based-learning-theories-from-the-journal-of-dynamic-teaching/* as on 7/11/2019.
- Keidinger, R.S. (2011). Brain-Based Learning and its Effects on reading Outcomes in Elementary Aged Students. Retrieved from: *https://pdfs.semanticscholor.org*. as on 6/11/2019.

- Krell, M. (2017). Evaluating an Instrument to Measure Mental Load and mental effort Considering Different sources of Validity Evidence. *Journal of Cogent Education, 4*(1), 1-10.
- Magno, N. C. (2018). Metacognitive Reading Strategy and Emerging Reading Comprehension in Students with Intellectual Disabilities. (Doctoral Dissertation). Retrieved from *https://scholarworks.waldenu.edu/cgi/viewcontent.cgi?article=6195&context=dissertations*
- Malamed, C. (2019). Meaning of Cognitive Load. Retrieved From: *https://theelearningcoach.com/learning/what-is-cognititve-load/* as on 6/11/2019.
- Ozden, M., & Gultekin, M. (2008). The Effect of Brain-Based Learning on Academic Achievement and Retention of knowledge in science course. *Electronic Journal of Science education, 12*(1), 1-17.
- Paas, F., Gog, T.V., & Sweller, J. (2010). Cognitive Load Theory: New Conceptualizations, Specifications, and Integrated Research Perspective. *International Journal of Educational Psychology Review, 22*(2), 115-121.
- Pass, F. G. (1992). Training Strategies for Attaining Transfer of Problem-Solving Skill in Statistics: A Cognitive-Load Approach. *Journal of Educational Psychology, 84*(4), 429.
- Prisacari, A. A., & Daneilson, J. (2017). Computer Based Verses Paper-Based Testing: Investigating Testing Mode with Cognitive Load and Scratch Paper use. *International Journal of Computers in Human Behaviour, 77*, 1-10.
- Ramakrishnan, J., & Annakodi, R. (2013). Brain-based Learning Strategies. *International Journal of innovative Research & Studies (IJIRS), 2*(5), 235-242.
- Rouse, M. (April, 2018). Cognitive Load Theory. Retrieved From: *https://Whatis.techtarget.com/definition/cognitive-load-theory-CLT* as on 7/11/2019.
- Siti N. H., Muhamad S.B., & Yusoff. (2016). Assessing the validity of the cognitive load scale in a problem-based learning setting. *Journal of Taibah University Medical Sciences, 11* (3), 194-202.

- Saleh, S. (2011). The Effectiveness of the brain-Based Teaching Approach in Generating Student's learning Motivation towards the subject of Physics: A qualitative Approach. *US-China Educational Review, 1,* 63-72.
- Shapiro, A. M. (2004). How Including Prior Knowledge As a Subject Variable May Change Outcomes of Learning Research. *Sage Journal: American Educational Research Journal, 41*(1), 151-189.
- Tufekci, S., & Demirel, M. (2009). The Effect of Brain-Based Learning on Achievement, Retention, Attitude and Learning Process. *Procedia-Social and Behavioural Sciences, 1*(1), 1782-1791.
- Varghese, Mary George & Pandya, Shefali (2016). A Study on the Effectiveness of Brain-Based- Learning of Students of Secondary Level on their Academic Achievement in Biology, Study Habits and Stress. *International Journal of Humanities and Social Sciences (IJHSS), 5*(2),103-122 ISSN (P): 2319-393X; ISSN (E): 2319-3948
- Wang, C. & Cesar, P. (2015). Physiological Measurement on Students' Engagement in a Distributed Learning Environment. *2nd International Conference on Physiological Computing Systems (PhyCS-2015*), 149-156.
- Wechsler, D. (2008). *The Wechsler Adult Intelligence Test (WAIS-IV).* Agra Psychological Cell: Agra.
- Wexley, K. N., & Nemeroff, W. F. (1975). Effectiveness of positive reinforcement and goal setting as methods of management development. *Journal of Applied Psychology, 60*(4), 446–450.